the embodiment of Fig. 3, despite the inductance of the current transformer 37 being extremely small.

Power received by the IC card 1 is input to the IC card processing unit 10 via a voltage regulator 41 and a filtering capacitor 42. The input signal is also passed through rectifying diodes 43, 44 coupled in parallel and in reverse polarity to each other. The voltage regulator 41, rectifying diodes 43, 44, and filtering capacitor 42 are all selected to provide an appropriate voltage (Vcc) to the IC card processing unit 10. The IC card processing unit 10 may include a central processor, memory, and other circuitry.

Data signals received by the IC card 1 are input to the IC card processing unit 10 via a signal receiving input circuit 9. Signal receiving input circuit 9 is formed from a voltage comparator 45 designed to output a clock signal to the IC card processing unit 10, and a second voltage comparator 46 for outputting data received from the transaction terminal 2 to the IC card processing unit 10. A diode 47 and a resistor 48 are positioned at the input of the first voltage comparator 45 to detect a clock signal received from the transaction terminal. Diodes 49, 50, resistor 51, and capacitor 52 are positioned to detect data signals received from the transaction terminal.

The IC card processing unit 10 is also coupled to send data to the transaction terminal 2. Data output from the IC card processing unit 10 passes through an actuating unit 11 for transformation into a serial code. The serial code output from the actuating unit 11 is supplied to a loading transistor 12. For the embodiments depicted in Figs. 2 and 3, the loading transistor is turned on when the serial data from the actuating unit is a logic "1" and is turned off when the serial data is a logic "0". When the loading transistor 12 is turned on, a load resistor 53 is added to the load of the IC card 1. As a result, the high frequency current flowing through the coil 33 increases. Similarly, referring briefly to the embodiment of Fig. 3, a high frequency current flowing through the diode bridge 16 increases. When the loading transistor 12 is turned off, the high frequency current

flowing through the coil 33 (or diode bridge 16, respectively) decreases. This high frequency current is detected by the coil 39 of the transaction terminal 2 and is converted by the amplifier 36 into a high frequency voltage input to the transaction terminal processing unit 3.

The result is an ability to transfer power and bi-directional data signals over the same pair of contacts while providing sufficient magnitudes of power to enable use of IC cards having large memories. In one specific embodiment, the IC card 1 is supplied with an input voltage of 8 Volts DC and a current magnitude of 200 mA, magnitudes not available in previous card designs.

Operation of embodiments of the present invention will now be described by referring to Fig. 2. When IC card 1 is brought into contact with the transaction terminal 2, the positive feedback circuit of amplifier 26 becomes a closed loop circuit via capacitive interfaces 18 and 19, matching capacitor 34, first inductive coil 33, primary coil 38 and quartz resonator 27. Similarly, referring briefly to the embodiment depicted in Fig. 3 the positive feedback circuit of amplifier 26 becomes a closed loop circuit via inductive coil 40, capacitive interfaces 18 and 19, matching capacitor 34, diode bridge 16, primary coil 38 and quartz resonator 27.

A series capacitance is formed by mating parallel plates 20 and 24, 21 and 25. As a result, amplifier 26 begins to oscillate in generator mode with a fixed amplitude output to provide an energy-transmitting alternating field through transformer 14 (in the embodiment of Fig. 2) or through diode bridge 16 (see the embodiment of Fig. 3) to IC card 1. In the embodiment of Fig. 2, the use of transformer 14 in conjunction with diodes 43, 44 provide full-wave rectifying of the received signal. Capacitor 42 smoothes and filters any high frequency voltage on the signal while voltage regulator 41 supplies the necessary supply voltage (e.g., Vcc) to IC card processing unit 10 and any other circuitry provided on IC card 1.

In the embodiment according to Fig. 3 where an inductive coil 40 is incorporated into transaction terminal 2

and a diode bridge 16 is supplied on the IC card 1, capacitor 42 is used to provide some preliminary smoothing of the received signal by filtering high frequency voltage which may exist on the signal. Voltage regulator 41 is used to further smooth the signal and to filter AC signals received from the transaction terminal 2. Voltage regulator 41 also provides the needed supply voltage to the IC card processing unit 10 and any other circuitry provided on the IC card 1.

At approximately the same time that amplifier 26 begins oscillating, card presence detector 54 generates a signal input to transaction terminal processing unit 3. This signal indicates that an IC card 1 has been inserted into the terminal, and that the terminal should commence interaction with the card. This signal received from the card presence detector, in one preferred embodiment, places the transaction terminal processing unit 3 in a waiting state where the processing unit is waiting for data to be received from the IC card 1.

The free running oscillation of amplifier 26 also causes an alternating field to be passed to IC card 1. The frequency of the free running energy-transmitting alternating field is used as the clock frequency for IC card processing unit 10 by passing from the IC card contacts 24, 25 through diode 47 and comparator 45 to a clock input of the IC card processing unit 10. IC card processing unit 10, in a specific embodiment, follows a communication protocol routine stored in, e.g., a read-only memory (ROM) in the processing unit. This routine may cause the IC card processing unit 10 to transmit specified data to the transaction terminal 2, such as security information, encryption data, and card or card-holder identification data. This information is transmitted as follows.

Data generated by the IC card processing unit 10 is transformed into a serial code by the actuating unit 11 and is then supplied to the loading transistor 12. It is assumed that the loading transistor is turned on when data is "1" and is turned off when data is "0". When the loading transistor 12 is turned on, there results in the addition of the load

resistor 53. Namely, a load when viewed from the side of second plurality of capacitive coupling means 17 increases. As a result a high frequency current flowing through the coil 33 increases (in the embodiment of Fig. 2), or, in the embodiment of Fig. 3, the high frequency current flowing through the diode bridge 16 increases. When the loading transistor 12 is turned off, the high frequency current flowing through the coil 38 (or diode bridge 16 of Fig. 3) decreases. This high frequency current is detected by the coil 39 and converted by amplifying means 36 into a high frequency voltage. Thereafter, the high frequency voltage is subjected to envelope detection and waveform shaping by the terminal processing unit 3. As mentioned above, terminal processing unit 3 may include signal processing functions known to those skilled in the art (such as envelope detection and waveform shaping). The received data may then be processed by the terminal processing unit 3 and may be forwarded to, e.g., the ATM network or processed locally.

When the data received in the transaction terminal 2 from the IC card 1 is processed by the terminal (and, in certain embodiments, is first deemed to be valid), the terminal starts to transmit data to the IC card 1. The signal modulation circuit 4 converts data signals from the transaction terminal processing unit into a serial code and supplies the serial coded data to the second input of amplifier 26. This provides amplitude modulation of the free running oscillations of the energy-transmitting alternating field.

Features of the invention allow the amplitude modulation of the transmitted signal to be varied by appropriate selection of the RC-parameters of circuit elements contained on the IC card 1 (i.e., by selecting the sizes and characteristics of diodes 49, 50, resistor 51, and capacitor 52). Similarly, envelope detection and waveform shaping is provided by selection of the comparator 46 and by the data sent to the IC card processing unit 10. The amplitude of envelope modulation is significantly less than the amplitude of free running oscillations of the energy-transmitting

alternating field and does not influence on the power transfer to the IC device module 1.

Referring briefly to Fig. 4, a perspective view of an IC card 1 as it is coupled to a host unit 2 is shown. As shown, conductive contact plates 20, 21 of the host unit are positioned to couple with conductive contact plates 24, 25 of the IC card. A user may simply position an IC card 1 over the host unit 2 to establish contact between the devices.

An alternative embodiment of an IC card 1 is illustrated in Fig. 5. In this alternative embodiment, the IC card 1 includes additional conductive plates 59 and 60 arranged on an opposite side of the IC card 1 from contacts 24, 25. These additional conductive contact plates 59, 60 are coupled electrically in pairs with contacts 24, 25. In this case the IC card 1 has a symmetric arrangement of capacitive coupling interfaces (59, 60 and 24, 25) so that a user can insert the card on either side to produce the same operation as described in conjunction with Figs. 1-3. This feature allows an IC card user to always properly insert an IC card into a transaction terminal, even under low light or other conditions which would otherwise cause the user to fumble with the card.

As will be appreciated by those familiar with the art, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. For example, although an ATM terminal and a smart card have been described, those skilled in the art will recognize that a number of other portable devices and host units may be implemented using features of the present invention. For example, cards compliant with Personal Computer Memory Card Industry Association (PCMCIA) requirements may be designed using features of the invention to capacitively mate with, e.g., a personal computer.

Accordingly, the disclosure of the invention is intended to be illustrative, but not limiting, of the scope of the invention which is set forth in the following claims.

WHAT IS CLAIMED IS:

1. A power and data transfer system, comprising:

a portable device having first contact circuitry, including a first pair of contact pads having an outer surface covered with a dielectric material, and a processing unit, coupled to said first contact circuitry;

a host unit having second contact circuitry, including a second pair of contact pads having an outer surface covered with a dielectric material, and a host processing unit, coupled to said second contact circuitry;

said first and second contact circuitry adapted to form a capacitive interface when said portable device is positioned proximate said host unit; and

said capacitive interface transmitting power signals from said host unit to said portable device and transmitting bi-directional data signals between said portable device and said host unit;

wherein said power signals and said bi-directional data signals are transmitted using the same said capacitive interface.

2. The power and data transfer system of claim 1, wherein said second contact circuitry further comprises:

at least a first matching capacitor having a capacitance selected to decrease a capacitance of said capacitive interface between said host unit and said portable device.

3. The power and data transfer system of claim 1, wherein said host unit further comprises an oscillation device coupled between said first contact circuitry and a portable device presence detector, said oscillation device adapted to oscillate when a portable device is positioned proximate said first contact circuitry.

4. The power and data transfer system of claim 3, wherein said portable device presence detector is adapted to

generate a portable device presence signal when said oscillation device begins to oscillate.

5. The power and data transfer system of claim 4, wherein said portable device presence signal causes said host processing unit to transmit data to said portable device.

6. The power and data transfer system of claim 1, wherein said host unit is an automated teller machine and said portable device is a smart card.

7. The power and data transfer system of claim 1, wherein said portable device further comprises:

an inductive network, coupled to said first contact circuitry;

power supply receiving circuitry coupled to receive power signals from said inductive network and to provide rectified electric current power signals to said processing unit of said portable device; and

signal receiving circuitry coupled to receive data signals from said inductive network and to provide detected and shaped data signals to said processing unit of said portable device.

8. The power and data transfer system of claim 6, wherein said inductive network is formed from a transformer having first and second inductive coils wound on a common core, said first inductive coil coupled to said first contact circuitry, and said second inductive coil coupled to said power supply receiving circuitry and to said signal receiving circuitry.

9. The power and data transfer system of claim 6, wherein said inductive network is formed from a diode bridge having a first terminal coupled to said signal receiving circuitry and a second terminal coupled to said power supply receiving circuitry.

10. A smart card adapted for use with a terminal, the terminal having a pair of conductive contacts covered with a layer of dielectric material, the smart card comprising:

a second pair of conductive contacts, covered with a layer of dielectric material;

a transformer having first and second inductive coils wound on a common core, said first inductive coil coupled to said second pair of conductive contacts and said second inductive coil coupled to a power circuit, to a signal receiving circuit, and to a signal transmitting circuit;

said power circuit receiving alternating current signals from said second inductive coil and generating a direct current power signal for input to a processing unit;

said signal receiving circuit receiving data signals from said second inductive coil and generating demodulated data and clock signals for input to said processing unit; and

said signal transmitting circuit receiving data signals from said processing unit and passing said data signals to said second inductive coil for transmission to said terminal over said second pair of conductive contacts.

11. A smart card adapted for use with a terminal having a pair of conductive contacts, the smart card comprising:

a second pair of conductive contacts, covered with a layer of dielectric material;

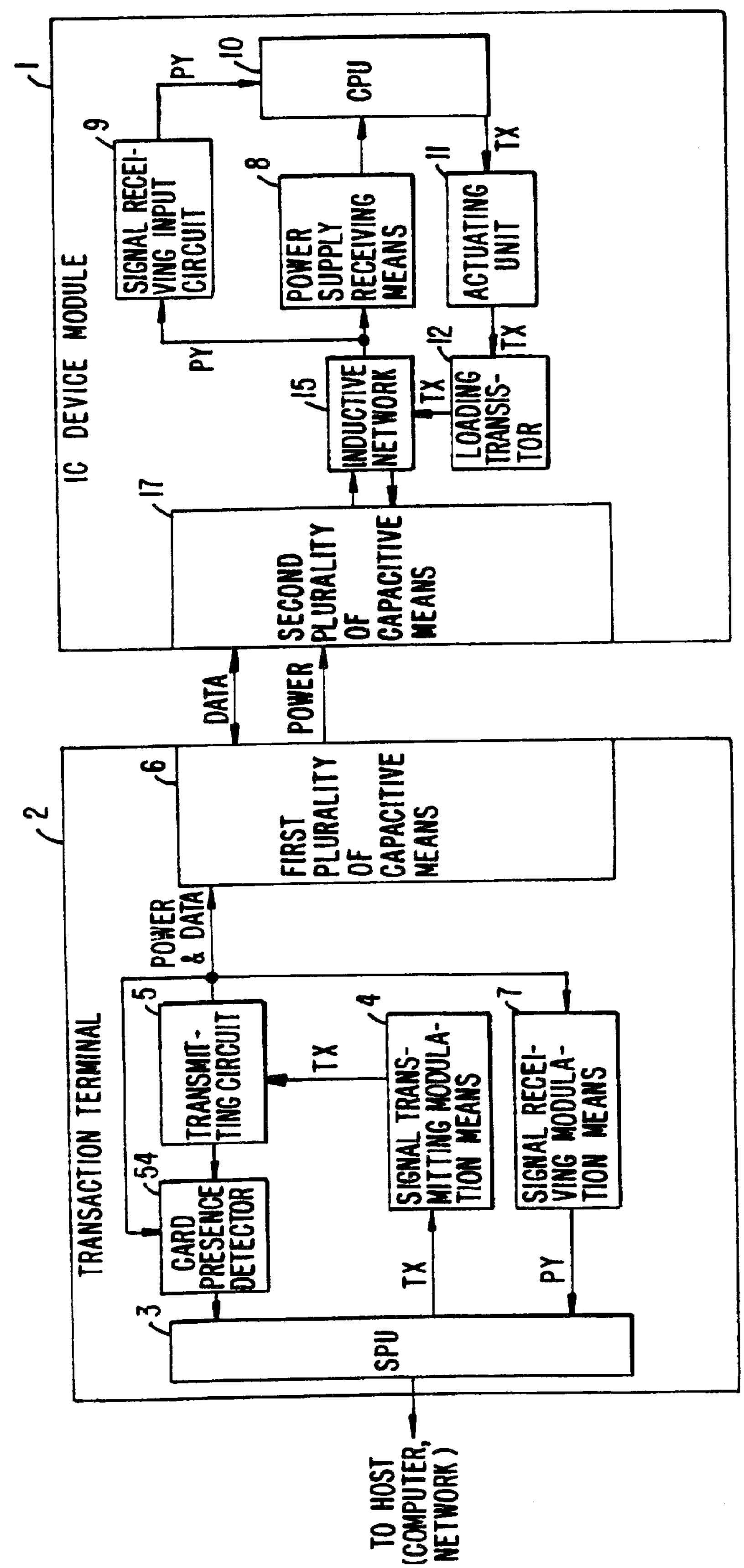
a diode bridge coupled to receive power signals from said second pair of conductive contacts and to send and receive data signals over said second pair of conductive contacts;

said diode bridge having a first terminal coupled to a signal receiving circuit, said signal receiving circuit receiving alternating current signals from said diode bridge and generating direct current data and clock signals for input to a processing unit;

said diode bridge having a second terminal coupled to a power receiving circuit, said power receiving circuit receiving alternating current signals from said diode bridge

and generating a direct current power signal for input to said processing unit;

a signal sending circuit, coupled to receive data signals from said processing unit and to pass said data signals to said diode bridge for transmission to said terminal over said second pair of conductive contacts.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9
POWER SUPPLY RECEIVING MEANS
8
ACTUATING UNIT
11
TX
INDUCTIVE NETWORK
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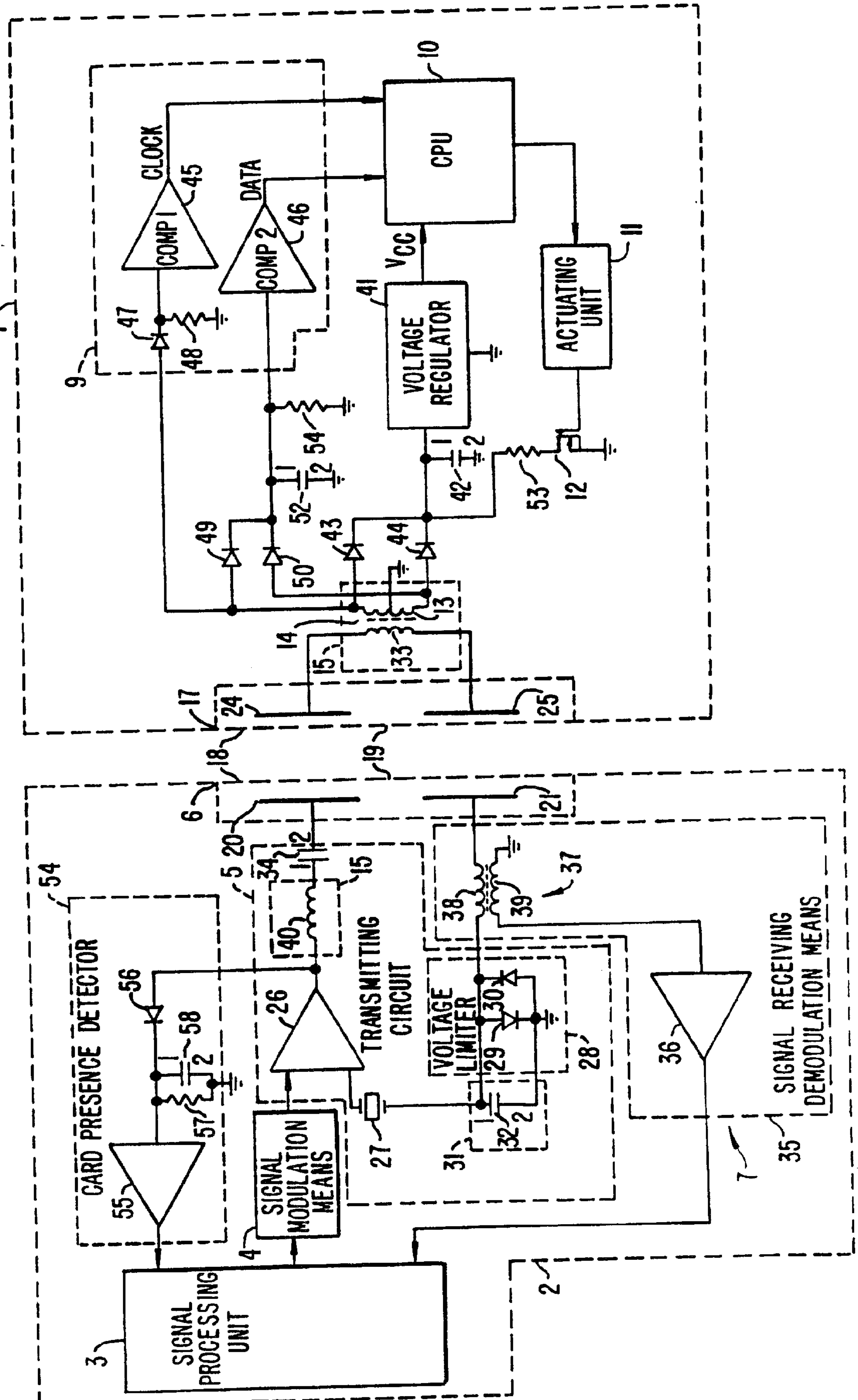
LOADING TRANSISTOR
12
SECOND PLURALITY OF CAPACITIVE MEANS
17
DATA
POWER
TRANSACTION TERMINAL
2
FIRST PLURALITY OF CAPACITIVE MEANS
6
POWER & DATA
TRANSMITTING CIRCUIT
5
SIGNAL TRANSMITTING MODULATION MEANS
4
SIGNAL RECEIVING MODULATION MEANS
7
CARD PRESENCE DETECTOR
54
SPU
3
TO HOST (COMPUTER, NETWORK)

FIG. 1.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CPU
VCC
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ACTUATING UNIT
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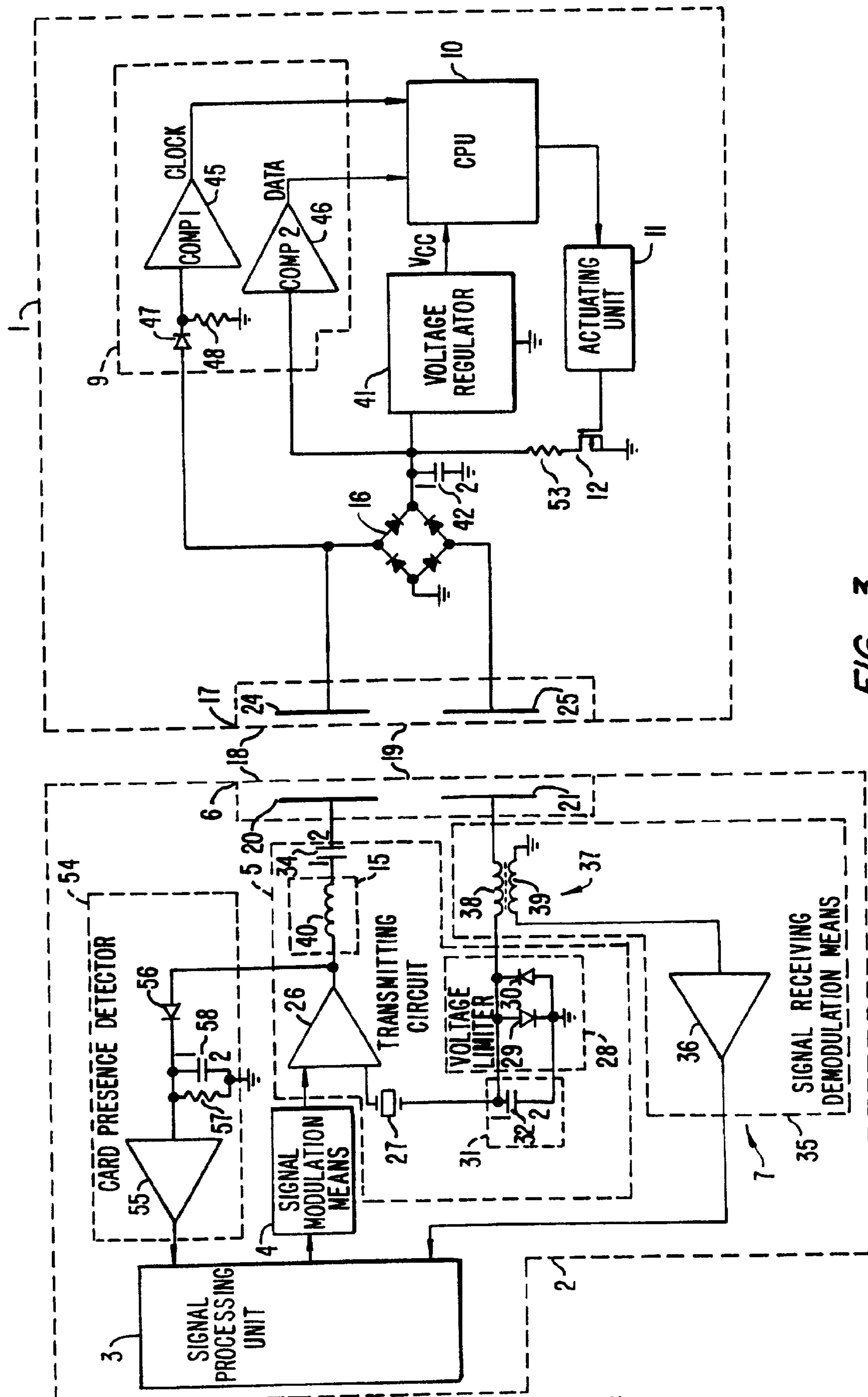
SIGNAL RECEIVING DEMODULATION MEANS
SIGNAL MODULATION MEANS
SIGNAL PROCESSING UNIT

FIG. 2.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SIGNAL PROCESSING UNIT

FIG. 3.

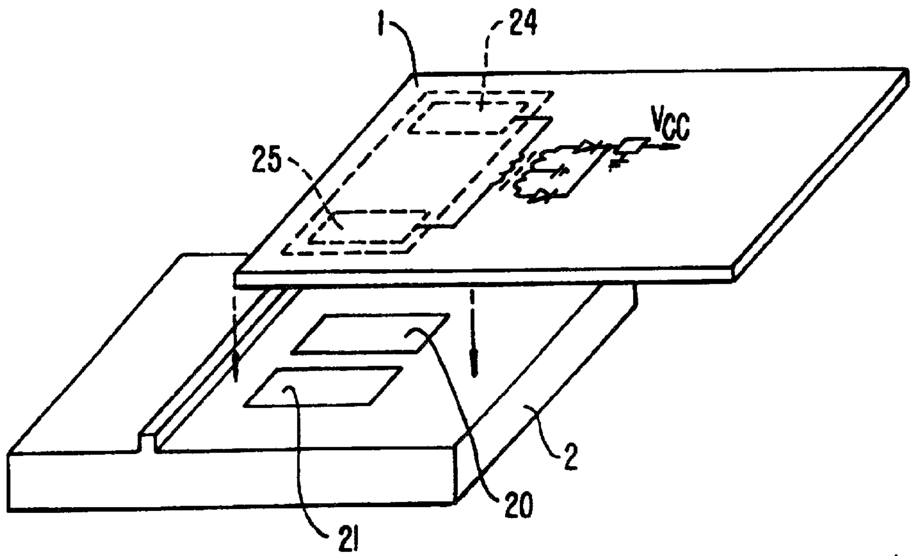

FIG. 4.

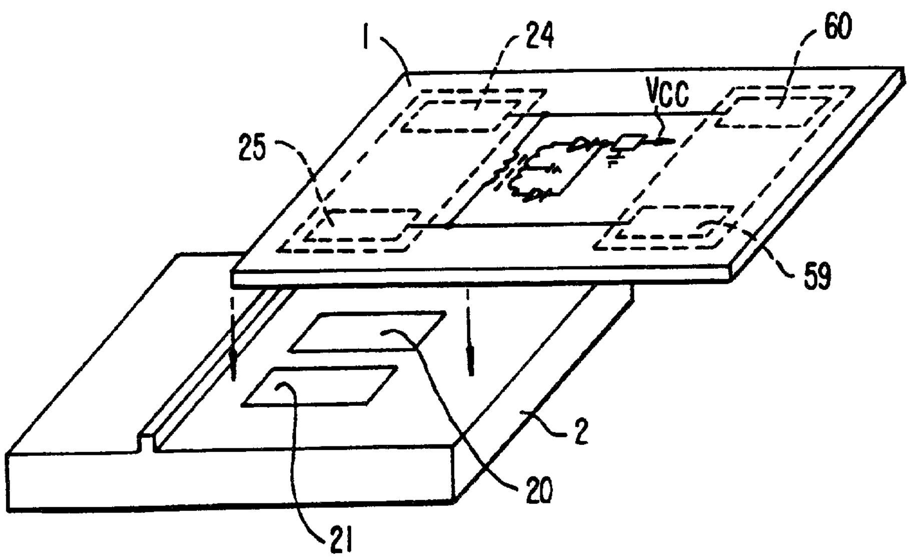

FIG. 5.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/11620

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : HO1L 23/02; G06K 7/08
US CL : 257/678, 679; 235/379, 380, 487, 488, 492
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 257/678, 679; 235/379, 380, 487, 488, 492

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,480,178 (MILLER, II ET AL) 30 OCTOBER 1984(30.10.84), FIGURE 1	1-9
Y	US 4,876,435 (BALLMER ET AL) 24 OCTOBER 1989(24.10.89), FIGURE 7.	1-9
X	U.S. 5,436,441 (INOUE) 25 JULY 1995(25.07.95), FIGURE 16.	11

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 27 SEPTEMBER 1997	Date of mailing of the international search report 15 OCT 1997
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